U.S. FISH AND WILDLIFE SERVICE

Draft Post-Delisting Monitoring Plan

for the

Magazine Mountain Shagreen
(*Inflectarius magazinensis*)

Prepared by:

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I. Summary of All Cooperators Roles in the Post-Delisting Monitoring Planning Effort

Post-delisting monitoring is a requirement of the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 *et seq.*). Section 4(g)(1) requires the Service to:

implement a system in cooperation with the States to monitor effectively, for not less than five years, the status of all species which have recovered to the point at which the measures provided pursuant to this Act are no longer necessary.

The purpose of post-delisting monitoring is to verify that Magazine Mountain shagreen (*Inflectarius magazinensis*) remains secure from the risk of extinction after it has been removed from the protections of the Act. The U.S. Fish and Wildlife Service (Service) prepared this draft post-delisting monitoring (PDM) plan (Plan), in coordination with the Arkansas Game and Fish Commission (AGFC), USDA Forest Service's Ozark-St. Francis National Forests (USFS), and Arkansas Department of Parks and Tourism (ADPT), based largely on the monitoring methods described in Robison (1996, pp. 6-24) and Caldwell *et al.* (2009, pp. 17-18). This draft Plan is designed to detect substantial declines in Magazine Mountain shagreen populations with reasonable certainty and precision. It meets the minimum requirement set forth by the Act by effectively monitoring the status of Magazine Mountain shagreen using annual sampling events.

All of the Magazine Mountain shagreen populations are located on lands owned by the USFS or ADPT. The USFS has been the principal party monitoring the recovery of this species. Caldwell (1986) conducted the first status survey of Magazine Mountain shagreen. Robison (1996, pp. 6-24) designed the first survey protocols to determine population parameters and trends. Prior to Caldwell *et al.* (2009), population and life history information concerning Magazine Mountain shagreen was nonexistent. Their work provided specific information on the geology and forest community of talus slopes occupied by Magazine Mountain shagreen. It also produced information on land snail associates, limiting factors, food habits, activity periods, and reproduction and growth of Magazine Mountain shagreen. The USFS monitored Magazine Mountain shagreen populations during May and June 1998 – 2011 using protocols described by Robison (1996, pp. 6-24).

II. Summary of Species Status at Time of Delisting

A. Demographic Parameters

Magazine Mountain shagreen is historically known from only the north slope of Magazine Mountain, Logan County, Arkansas (Pilsbry and Ferriss 1907, p. 545; Caldwell *et al.* 2009, p. 4). The south slopes of Magazine Mountain were surveyed extensively by Caldwell (1986 in Service 1994, p. 3) and Caldwell *et al.* (2009, p. 4), but they did not find Magazine Mountain shagreen on the south slopes. Populations occur in the vegetated and leaf litter covered portion of talus (a sloping mass of loose rocks) at an

elevation of 2,200 feet (ft; 670.6 meters (m) to 2,600 ft (792.5 m) in the Savanna Sandstone formation calved (broken off or splintered into pieces) due to weathering and erosion of interbedded shales (Caldwell *et al.* 2009, p. 4; Service 1994, p. 3). The majority of talus is above 2,200 ft (670.6 m) elevation on the north and west slopes, with Magazine Mountain shagreen populations occurring between 2,400 ft (731.5 m) and 2,600 ft (792.5 m). In the north slope of Bear Hollow, the talus begins at approximately 2,200 ft (670.6 m) and in some calved areas extends to near 2,265 ft (690.4 m) elevation. In Bear Hollow, Magazine Mountain shagreen is restricted to the upper vegetated elevation end of this talus range (Caldwell *et al*. 2009, pp. 4–5).

Magazine Mountain shagreen prefers moist woods with some noteworthy differences in the tree and shrub communities present on the north and south slopes of Magazine Mountain (Caldwell *et al*. 2009, pp. 15-16). For example, trees such as *Tilia americana* (American linden), *Acer sacccharum* (sugar maple), *Fraxinus americana* (white ash), and *Ribes cynosbati* (prickly gooseberry) were found only on the north slopes of Magazine Mountain (Caldwell *et al.* 2009, pp. 6-11).

There is no significant difference among ground, atmospheric, and rock crevice maximum temperatures between the north and south slopes on Magazine Mountain. However, significant differences do exist for minimum temperatures. Ground, atmospheric, and rock crevice minimum temperatures were 37.6, 37.2, and 35.6 degrees Fahrenheit (°F) (3.1, 2.9, and 2.0 degrees Celsius (°C), respectively) cooler on the north slopes than the south slopes (Caldwell *et al.* 2009, p. 15). Mean average rainfall at the summit of Magazine Mountain is 55 inches (in.; 139.7 centimeters (cm)), approximately 5 in. (12.7 cm) greater than lower elevations (Service 1994, p. 3).

Magazine Mountain shagreen were found during night surveys feeding on oak catkins (flowers), algal covered rocks, and decaying *Quercus alba* (white oak) leaves. It has generalist feeding habits (able to utilize many food sources) similar to other land snails in the taxonomic family Polygyridae (Foster 1936, pp. 26–31; Blinn 1963, pp. 501–502; Dourson 2008, pp. 155–156; Caldwell *et al*. 2009, p. 16). Thus, food source probably is not a limiting factor for Magazine Mountain shagreen (Caldwell *et al*. 2009, p. 16).

In 1986, Caldwell (1986) failed to find Magazine Mountain shagreen egg masses, but he suspected that eggs were laid deep within the talus (Service 1994, p. 3). Caldwell *et al*. (2009, p. 15–16) located Magazine Mountain shagreen egg masses the second week of May concurrent with spring rain. The egg masses were not laid deep within the talus as previously hypothesized. Temperatures of the substrate and rock were 63.7 and 64.2 °F (17.6 and 17.9 °C), respectively.

Caldwell *et al*. (2009, p. 15) collected one egg mass containing 13 eggs (diameter 0.1 in. or 2.7 mm) and successfully hatched and reared Magazine Mountain shagreen juveniles in a terrarium at room temperature (73 °F or 23 °C). Ten of 13 eggs hatched after a five-week incubation period. Magazine Mountain shagreen young hatched at a size of 0.1 in. (3.5 mm).

No live Magazine Mountain shagreen individuals or egg masses were located from June through March during the two-year survey. Therefore, Caldwell *et al*. (2009, p. 16) suspected that Magazine Mountain shagreen lay eggs only during early spring (late April–early May) and that egg-laying is triggered by spring rains. They noted that the first onset of oak catkins concurrent with rain events serves as a visual cue to locate live individuals and egg masses.

Little information is available on land snail associations (*e.g.*, presence/absence of other land snails to predict habitat quality or occurrence of Magazine Mountain shagreen). Caldwell *et al*. (2009, pp. 13–14) determined the relative abundance (number of a particular species as a percentage of the total population of a given area) of species found with Magazine Mountain shagreen. Land snails such as the blade vertigo (*Vertigo milium*) and pale glyph (*Glyphyalinia lewisiana*) were found only on the south slope talus, while the oakwood liptooth (*Millerelix dorfeuilliana*) and immature Succineidae species were found on the north slope talus. Thus, presence of oakwood liptooth and immature Succineidae in habitats suitable for Magazine Mountain shagreen may predict its occurrence despite negative survey results.

B. Discussion of Populations

In developing the monitor strategy for Magazine Mountain shagreen, 10 specific sampling stations were established in 1996 that would later serve as the long-term monitoring locations for the USFS (Figs. 1–3). Each station was marked with permanent markers so that later annual monitoring effort could be repeated at the exact location (Robison 1996, p. 6). The survey protocol uses Visual Encounter Searches (VES) to determine, map, and monitor Magazine Mountain shagreen population parameters and its habitat (Robison 1996, pp. 7–24). VES involves field personnel walking through an area or habitat for a prescribed time period systematically searching for animals and has been used effectively with amphibians in habitats that are widely spaced such as the talus slopes Magazine Mountain shagreen inhabits (Crump and Scott 1994 in Robison 1996, pp. 8-9). The assumption of VES is that the shorter duration in time to encounter an animal, the more common and abundant the animal is at any particular site (Robison 1997, p. 7).

Historic surveys for Magazine Mountain shagreen prior to development of the 1994 Recovery Plan were limited to two surveys: 1) a 1903 collection of 114 live specimens and one dead specimen from the north and south slopes of Magazine Mountain (Pilsbry and Ferriss 1906, p. 545), and 2) a comprehensive status review by Caldwell (1986). Neither survey reported population estimates or catch per unit effort. Therefore, it is not possible to make a comparative analysis of these collections to subsequent collections that reported number of live and dead snails per search time (see discussion below).

In 1996, two surveys were conducted for Magazine Mountain shagreen at each of the 10 sampling stations (Table 1; Robison 1996, pp. 17–20). Using VES, live Magazine Mountain shagreen were found at four sampling stations on May 24–27, 1996 and four stations on June 6–8, 1996 (Table 1; Robison 1996, p. 19). At all sites, dead Magazine

Figure 1. Magazine Mountain shagreen long-term monitoring Sites 1 – 6
(Caldwell *et al.* 2009, Map 1)

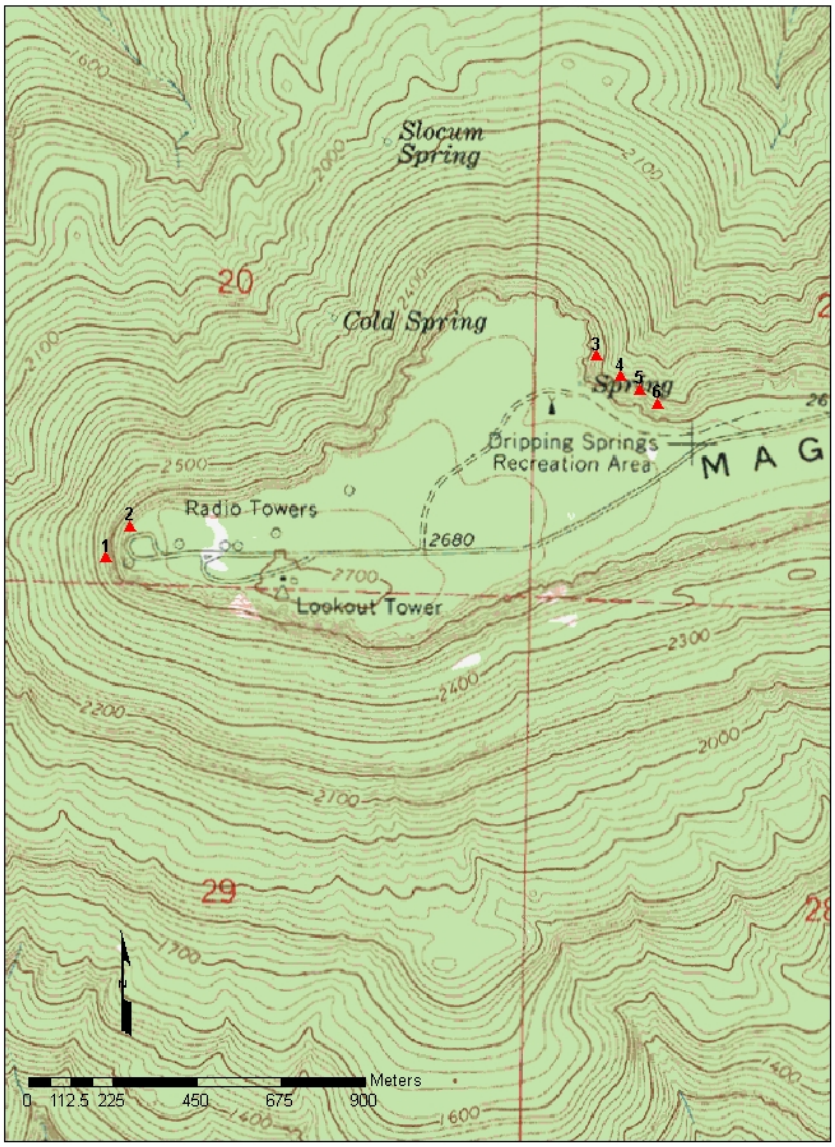

Figure 2. Magazine Mountain shagreen long-term monitoring Sites 7 – 9 (Caldwell *et al.* 2009, Map 2)

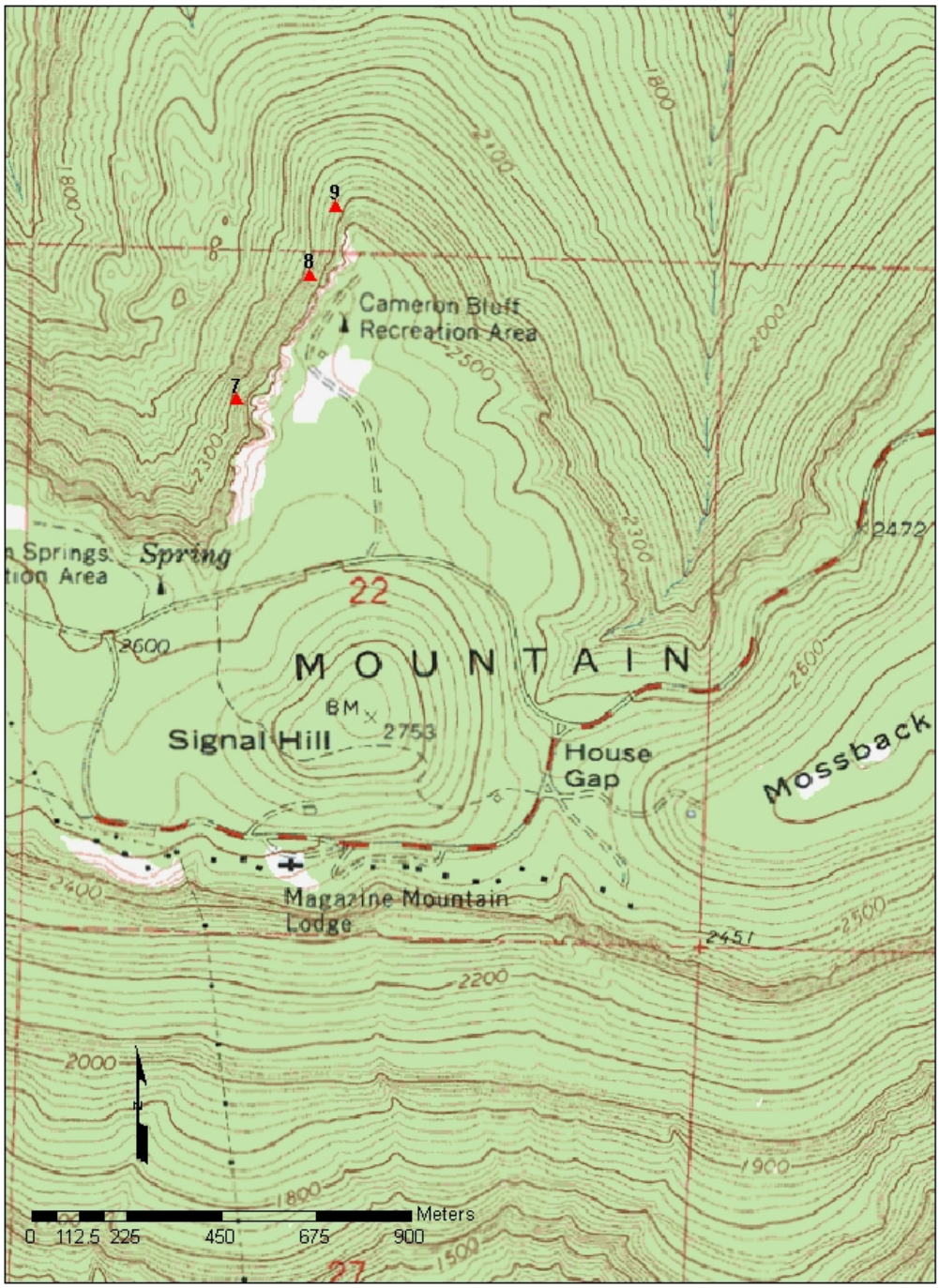

Figure 3. Magazine Mountain shagreen survey site in Bear Hollow
(Caldwell *et al.* 2009, Map 3)

Table 1. Results of timed searches conducted in 1996 and 1997 at 10 Magazine Mountain shagreen (MMS) monitoring stations on Magazine Mountain, Logan County, Arkansas (Robison 1996, pp. 33-35; Robison 1997, pp. 16-17). Time is reported in minutes to first encounter. The number of individuals collected is for a 60-minute search period or number of individuals per hour at each station (catch per unit effort).

Station	Dead MMS Shell						Live MMS					
	24-27 May 1996		6-8 June 1996		19-20 May 1997		24-27 May 1996		6-8 June 1996		19-20 May 1997	
	Number	Time (min)	Number	Time (min)	Number	Time (min)	Number	Time (min)	Number	Time (min)	Number	Time (min)
1	0	0	0	0	0	0	0	0	0	0	0	0
2	1	11	1	10	0	0	0	0	0	0	0	0
3	5	6	0	0	3	8	3	7	0	0	2	13
4	3	5	2	7	1	9	0	0	0	0	0	0
5	3	16	4	12	2	17	2	18	2	18	1	30
6	2	4	1	9	4	8	2	12	1	10	1	19
7	2	12	2	6	1	14	0	0	1	9	1	46
8	3	4	2	7	0	0	1	9	2	13	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
Total # of individuals or shells	19	------	12	------	11	------	8	-------	6	-------	5	------
Average time to encounter	------	8.3	------	8.5	------	11.2	------	11.5	------	12.5	------	27

Mountain shagreen shells were encountered before live individuals were discovered (Table 1). Magazine Mountain shagreen shell size was comparable between 1986 and 1996: mean height/width ratio was 0.55 (range 0.52–0.59, N = 18; Caldwell 1986) and 0.64 (range 0.50–0.61, N = 25; Robison 1996, p. 38), respectively.

A third survey was conducted by Robison in May 1997 (Table 1; Robison 1997, pp. 16-17). Live individuals and dead shells were found at four and five sampling stations, respectively (Table 1). Magazine Mountain shagreen shell size (height/width ratio) in 1997 was within the range of shell size measurements collected during the 1986 (Caldwell 1986) and 1996 (Robison 1996, p. 38) surveys.

The USFS conducted Magazine Mountain shagreen population monitoring from 1998 through 2011 using the same sampling protocols and 10 stations established by Robison (1996). Station 10 was dropped from surveys in 2002, with Service approval, since no live or dead Magazine Mountain shagreen had been collected at this station during any previous surveys. One person hour (60 minutes) per station was spent searching for Magazine Mountain shagreen in all survey years (1998–2011, except during 2000 when no surveys were conducted and 2007 when three stations were not sampled). The number of live and dead Magazine Mountain shagreen collected at each station from 1998–2011 are shown in Table 2. The amount of time (minutes) that elapsed until the first encounter of live and dead Magazine Mountain shagreen at each station from 1998–2011 are shown in Table 3.

Overall, the number of live Magazine Mountain shagreen collected annually from 1996–2011 shows that the species is persisting over time; annual fluctuations in numbers of individuals is likely attributable to climatic and/or temporal conditions (Tables 1–3). For example, monitoring conducted in mid-June 2009 yielded zero live Magazine Mountain shagreen. However, June 2009 was considerably drier than May 2009 (3.74 in. (95 mm) vs. 11.85 in. (301 mm)) monthly rainfall, respectively; 5 versus 13 days with rainfall, respectively) and likely explains the lack of live specimens observed during the survey because the snails are more active during times of high humidity and cooler temperatures (USFS 2009, pp.1, 4–5).

The number of dead Magazine Mountain shagreen collected annually from 1996–2011 has shown greater annual fluctuation than the number of live individuals (Tables 1–3). A closely related species, shagreen (*I. inflectus*), is slightly smaller than Magazine Moutain shagreen with a “greater diameter” ranging from 0.37-0.44 in. (9.5 to 11.3 mm) (mean = 0.43 in. (10.9 mm.)) compared to 0.50-0.55 in. (12.7 to 14.0 mm) (mean = 0.52 in. (13.3 mm)) for Magazine Mountain shagreen (Caldwell *et al.* 2009, p. 2). However, individuals of shagreen, on which aperture (the main opening of the snail’s shell) teeth are reduced, look very similar to Magazine Mountain shagreen. Therefore, accurate identification of dead Magazine Mountain shagreen, and to a much lesser extent live individuals, may be easily confused with the more common and abundant shagreen depending on surveyor experience, which has been variable during the 16-year monitoring period.

Table 2. Number of individuals located during 60-minute search periods at 10 Magazine Mountain shagreen (MMS) monitoring stations on Magazine Mountain, Logan County, Arkansas from 1998 to 2011 (USFS unpublished data sheets 1999-2011, USFS 2009). The number of individuals collected is for a 60-minute search period or number of individuals per hour at each station (catch per unit effort). D = dead shells; L = live snails; NS = not sampled; NR = not recorded; DM = data missing from USFS files.

Station	Dead(D) or Live (L)	Year														
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	1998-2011
1	D	0	0	NS	1	0	0	0	0	0	NR	0	0	0	0	1
	L	0	1	NS	0	2	0	1	2	0	2	0	0	0	0	8
2	D	0	1	NS	0	0	0	0	2	DM	NR	0	0	0	0	3
	L	0	0	NS	0	0	0	1	0	DM	2	0	0	0	0	3
3	D	0	0	NS	1	0	0	0	0	0	NS	0	0	0	0	1
	L	0	0	NS	0	0	0	0	0	0	NS	0	0	0	0	0
4	D	2	1	NS	2	0	1	1	0	0	NR	1	1	1	0	10
	L	1	0	NS	0	0	0	0	0	0	1	2	0	0	0	4
5	D	0	0	NS	1	1	1	3	0	0	NS	1	3	5	0	15
	L	1	1	NS	1	0	0	3	3	2	NS	3	0	0	1	15
6	D	2	0	NS	3	0	0	4	NR	0	NR	0	1	4	0	14
	L	2	0	NS	2	0	2	3	4	1	1	0	0	0	0	15
7	D	4	0	NS	0	0	0	1	0	DM	0	0	0	1	0	6
	L	0	0	NS	0	0	0	0	2	DM	1	0	0	0	3	6
8	D	0	0	NS	0	0	1	0	0	0	NS	1	1	2	0	5
	L	0	0	NS	0	0	0	1	2	0	NS	1	0	0	0	5
9	D	0	0	NS	0	0	0	0	0	0	NR	0	0	0	0	0
	L	0	0	NS	0	2	0	0	0	1	1	0	0	0	0	4
10	D	0	0	NS	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0
	L	0	0	NS	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0
Totals	D	8	2	NS	8	1	3	9	2	0	NR/NS	3	6	13	0	55
	L	4	2	NS	3	4	2	9	13	4	8	6	0	0	4	59
	D + L	12	4	NS	11	5	5	18	15	4	8	9	6	13	4	114

Table 3. Minutes to first encounter of Magazine Mountain shagreen individual. Results of timed searches conducted by the USFS at 10 Magazine Mountain shagreen (MMS) monitoring stations on Magazine Mountain, Logan County, Arkansas from 1998 to 2011 (USFS unpublished data sheets 1999-2011, USFS 2009). Numbers reported are for time (minutes) to first encounter of a dead shell or live snail. Timed searches were conducted for 60 minutes at each station in each year, except where otherwise indicated. D = dead shells; L = live snails; NS = not sampled; NR = not recorded; DM = data missing from USFS files.

Station	Dead(D) or Live (L)	Year													
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	D	0	0	NS	30	0	0	0	0	0	NR	0	0	0	0
	L	0	11	NS	0	8	0	10	1	0	16	0	0	0	0
2	D	0	42	NS	0	0	0	0	10	DM	59	0	0	0	0
	L	0	0	NS	0	0	0	37	0	DM	44	0	0	0	0
3	D	0	0	NS	42	0	0	0	0	0	NS	0	0	0	0
	L	0	0	NS	0	0	0	0	0	0	NS	0	0	0	0
4	D	12	1	NS	52	0	14	15	0	0	NR	55	55	20	0
	L	18	0	NS	0	0	0	0	0	0	50	30	0	0	0
5	D	0	0	NS	12	2	1	30	0	0	NS	1	8	50	0
	L	36	27	NS	2	0	0	32	13	21	NS	30	0	0	60
6	D	45	0	NS	8	0	0	26	6	0	NR	0	42	3	0
	L	16	0	NS	2	0	10	26	10	19	1	0	0	0	0
7	D	53	0	NS	0	0	0	31	0	DM	0	0	0	29	0
	L	0	0	NS	0	0	0	0	3	DM	11	0	0	0	20
8	D	0	0	NS	0	0	6	0	0	0	NS	55	50	12	0
	L	0	0	NS	0	0	0	32	1	0	NS	50	0	0	0
9	D	0	0	NS	0	0	0	0	0	0	NR	0	0	0	0
	L	0	0	NS	0	1	0	0	0	18	7	0	0	0	0
10	D	0	0	NS	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	L	0	0	NS	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average Time to Encounter	D	37	22	NS	29	2	7	26	8	0	59	37	39	29	0
	L	23	19	NS	2	5	10	27	6	19	22	37	0	0	40

There are numerous problems with sampling populations of terrestrial snails, including their rupicolous nature (living or growing on or among rocks), which makes it difficult to locate individuals during surveys, effects of climate variables (*e.g.*, temperature and humidity) on snail activity, and practicality of surveys for nocturnal species such as Magazine Mountain shagreen (Newell 1971 and Bishop 1977 in Robison 1996, p. 7). Surveys are optimally conducted at night in late April to early May, dependent upon the onset of spring (moister conditions at the surface, emergence of oak catkins, temperature) (Caldwell *et al.* 2009, p. 17). A rise in relative humidity and drop in temperature usually causes land snails to become more active (Burch and Pearce 1990 in Robinson 1996, p. 7). Therefore, climatic and temporal variation may explain variation in number of live specimens collected from one survey to the next.

Population size, density, and age structure cannot be reliably estimated for a rupicolous species that spends most of the year deep within the talus slopes of Magazine Mountain (Caldwell *et al.* 2009, p. 4). Therefore, these population parameters have not been estimated for this species.

All talus habitats inhabited by Magazine Mountain shagreen were assessed and spatially mapped in 2007–2008 (Caldwell *et al.* 2009, pp. 23–31). According to that assessment, the total amount of available habitat for Magazine Mountain shagreen consists of approximately 21.6 ac (8.75 ha) at 27 talus habitats on Magazine Mountain's west and north slopes (Figs. 4–6; Caldwell *et al*. 2009, pp. 4–5). The only other habitat assessment for Magazine Mountain shagreen was conducted in 1986 during a comprehensive status review (Caldwell 1986). In 1986, total habitat available to the species was estimated at 540 ac (218.5 ha). No habitat loss has occurred since 1986, but rather more advanced technology using global positioning satellite (GPS) mapping of talus habitat and detailed analysis of vegetative communities and climatic variables provided a more accurate assessment of the species' habitat.

Figure 4. Magazine Mountain shagreen habitat near Radio Towers and Dripping Springs Area (Caldwell *et al.* 2009; Map 6).

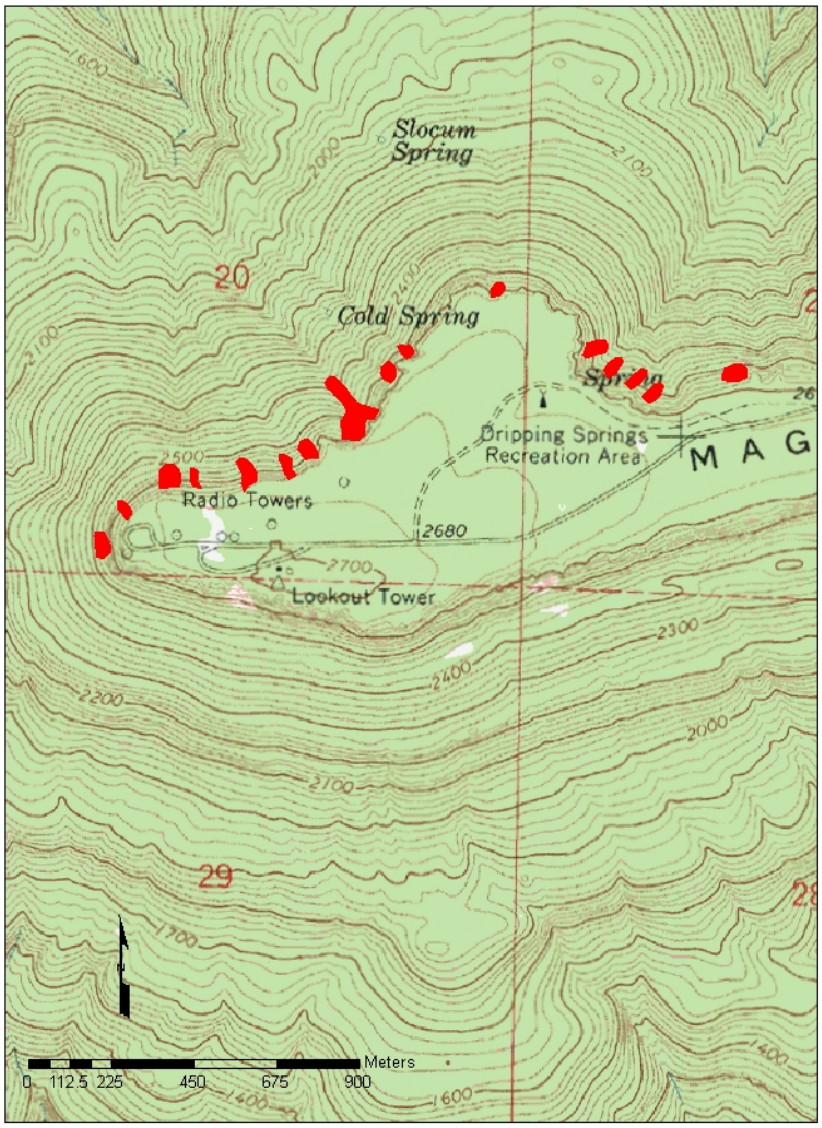

Figure 5. Magazine Mountain shagreen habitat in Brown Springs and Cameron Area (Caldwell *et al.* 2009; Map 6).

Figure 6. Magazine Mountain shagreen habitat in Bear Hollow
(Caldwell *et al.* 2009; Map 6).

C. Residual Threats

The final rule to list Magazine Mountain shagreen as threatened (54 FR 15206) identified the following habitat threats: possible negative effects from USFS use of the land, a military proposal that would bring heavy equipment into the species habitat, and the development of a new state park and lodge on Magazine Mountain. All of these threats have been abated and/or alleviated through consultation with the Service. We believe that the protected status of the lands where Magazine Mountain shagreen currently exists will continue to provide adequate regulatory protection for this species and its habitat.

Caldwell *et al.* (2009, p. 18) cited wild fires as the single greatest threat to Magazine Mountain shagreen. The USFS's prescribed fire program and its associated timing and frequency will reduce the likelihood of catastrophic wild fires. The prescribed fire program also provides a buffer around Magazine Mountain shagreen habitat (USFS 2007, pp. 9-10). The ADPT restricts campfires and open flame cooking to designated areas to minimize the potential for wild fires that may potentially threaten Magazine Mountain shagreen and its habitat and State Park buildings and structures.

The final listing rule for Magazine Mountain shagreen (54 FR 15206) identified the restricted range (Magazine Mountain) and temperature and moisture as potential stressors to Magazine Mountain shagreen. The Intergovernmental Panel on Climate Change (IPCC) concluded that evidence of warming of the climate system is unequivocal (IPCC 2007a, p. 30). Numerous long-term climate changes have been observed including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2007b, p. 7). While continued change is certain, the magnitude and rate of change is unknown in many cases. Species that are dependent on specialized habitat types, that are limited in distribution, or that have become restricted to the extreme periphery of their range will be most susceptible to the impacts of climate change. As stated above, Magazine Mountain shagreen is only found on the north and west slopes of Magazine Mountain, Logan County, Arkansas in the vegetated and leaf litter covered portion of talus rock between 2,200 ft (670.6 m) and 2,600 ft (792.5 m).

Estimates of the effects of climate change using available climate models lack the geographic precision needed to predict the magnitude of effects at a scale small enough to discretely apply to the range of Magazine Mountain shagreen. However, data on recent trends and predicted changes for the Southeast United States (Karl *et al.* 2009, pp. 111-116) provide some insight for evaluating the potential threat of climate change to Magazine Mountain shagreen. Since 1970, the average annual temperature of the region has increased by about 2 ^{o}F (1.1 ^{o}C), with the greatest increases occurring during winter months. The geographic extent of areas in the Southeast region affected by moderate to severe spring and summer drought has increased over the past three decades by 12 and 14 percent, respectively (Karl *et al.* 2009, p. 111). These trends are expected to increase.

Rates of warming are predicted to more than double in comparison to what the Southeast

has experienced since 1975, with the greatest increases projected for summer months. Depending on the emissions scenario used for modeling change, average temperatures are expected to increase by 4.5 ^{o}F to 9 ^{o}F (2.5 ^{o}C to 5 ^{o}C) by the 2080s (Karl *et al.* 2009, pp. 111). While there is considerable variability in rainfall predictions throughout the region, increases in evaporation of moisture from soils and loss of water by plants in response to warmer temperatures are expected to contribute to the effect of these droughts (Karl *et al.* 2009, pp. 112).

Since Magazine Mountain shagreen prefers cool, moist microhabitats, prolonged drought or concomitant warming of temperatures could adversely affect the species. In particular, nesting sites and egg masses may be affected (Caldwell *et al.* 2009, p. 15). However, there is no data to establish that such effects are reasonably certain to occur. Therefore, we do not have any evidence to suggest that climate change is a threat to Magazine Mountain shagreen now or within the foreseeable future.

Therefore, we anticipate that the status of Magazine Mountain shagreen will remain secure after delisting under the Act because recovery efforts have eliminated threats to the species and secured habitat that support self-sustaining populations distributed among 27 talus slopes on Magazine Mountain (Figures 4–6).

D. Legal and/or Management Commitments for Post-delisting Conservation

The 27 talus slopes on Magazine Mountain supporting Magazine Mountain shagreen occur entirely on public lands in either State or Federal ownership. It is not known how many distinct populations are represented within these 27 talus slopes on the west and north slopes of Magazine Mountain. Based on the life history and rupicolous nature of this species, it is plausible to assume that each talus slope may represent a unique population, and therefore should be appropriately managed as a separate population until better scientific information is available to delineate individual populations. Bear Hollow appears to be a distinct population based on its isolation from the 26 remaining talus slopes occupied by Magazine Mountain shagreen.

We believe that the 27 talus habitats on Magazine Mountain's north and west slopes that support Magazine Mountain shagreen are secure for the foreseeable future from the threats affecting the species at the time of listing. The entire range of the species and its habitat is located on protected public land. We believe that land management on Magazine Mountain precludes threats due to residential, recreational, or commercial development and other land use activities that may adversely alter habitat for the foreseeable future. We expect that the delisting of Magazine Mountain shagreen will not lessen the USFS's or ADPT's commitment to the conservation of Magazine Mountain shagreen and its habitat.

The USFS is the agency responsible for managing Magazine Mountain shagreen populations on Magazine Mountain. The USFS Magazine Mountain Special Interest Area (SIA) is managed for its unique geological, botanical, biological, zoological, scenic, or cultural features. The features are unique enough that they are not found on large areas anywhere else on the USFS Ozark-St. Francis National Forests, or they provide the best representation of similar areas on the Forests. These areas are designated as SIAs because

of their unique features, complexity, and degree of interest. Each SIA has a comprehensive management plan completed before capital investments are implemented (USFS 2007). The SIA designation prohibits timber harvest, prescribed burning from leaf fall until the end of Magazine Mountain shagreen reproductive period, application of aerial fire retardant, road construction, and recreational development on talus slopes (USFS 2005, pp. 2-43 – 2-44). Desired conditions within the SIAs include, but are not limited to:

1. The unique qualities of the SIAs of the Ozark-St. Francis National Forests are predominately geologic, scenic, or botanical.

2. Public access is designed to protect sensitive resources; access to some SIAs may be limited in order to protect resources.

III. Monitoring Methods and Locations

The PDM methods used for Magazine Mountain shagreen are those developed by Caldwell *et al.* (2009, pp. 17-18) based upon experience in studies of three similar rupicolous snail species and new life history and ecology information on Magazine Mountain shagreen.

A. Definitions of Terms

Rupicolous – thriving among or inhabiting rocks. Magazine Mountain shagreen spends most of the year underground in talus habitat.

Talus – a sloping mass of loose rocks

B. Procedures for Selecting and Locating Samples

Cameron and Pokryszko (2005) outline quadrat and volumetric standard methods used in land snail surveys, listing strengths and weaknesses and suggesting how both procedures may best be utilized. Mollusk species and individuals are rarely, if ever, distributed at random in a site. They are usually aggregated, sometimes to an extreme degree (Cameron 1982 and Sharland 2001 in Cameron and Pokryszko 2005, p. 536). There are differing levels of detectability among species, dependent on the method of sampling used, and especially on season and weather. This is especially true with Magazine Mountain shagreen, and problems with adequate or reliable sampling are exacerbated by its rupicolous nature (Caldwell *et al.* 2009, p. 17).

Random quadrat sampling is the most frequently applied sampling technique for mollusks. The quadrats are usually 20 x 20 or 25 x 25 cm, and the total area from which material is removed is usually in the range of one to four m^2 (Cameron and Pokryszko 2005, p. 537). Cameron and Pokryszko (2005, pp. 537-539) identify two major sources of error that are

possible when considering the life history and ecology of land snails similar to Magazine Mountain shagreen:

1. Abundance and distribution make quantitative sampling of land snails very inefficient. Rock dwelling species such as Magazine Mountain shagreen occupy microhabitats that are patchily distributed within talus slopes, and individuals therefore may escape sampling. They also live underground for a large portion of the year, which makes sampling season and weather critical for sampling.

2. Seasonal variation in density and micro-distribution. Many snail species have short life cycles, and their density undergoes drastic seasonal fluctuations. Some snail species show apparent decline in density under unfavorable conditions, such as drought. Finally, reasons for seasonal aggregation are not always clear, and patterns can change with season.

Larger snails, such as Magazine Mountain shagreen, are often missed or underrepresented in quantitative samples because they occur at low densities and tend to be locally aggregated, while small litter-dwelling species are more efficiently retrieved in quadrats than through visual search. Due to the immense variability associated with quadrat samples, some scientists choose to sieve a definitive volume of litter and soil from patches selected non-randomly within a defined area. When quantitative results are needed they can be standardized either by taking the same volume of litter at each site or by estimating mean number of individuals of each species per unit of volume. Volumetric methods, while more dependent on investigator skill and professional judgment, give more consistent results when two sites with similar environmental conditions are compared. However, volumetric method is strictly incomparable in terms of absolute density due to impossible conversion from number per liter to individuals/m^2. Generally, the volume method is combined with a visual search in a defined area because it improves the chance of finding small and cryptic species. When comparing quadrat to volumetric methods, the two methods differ in overall efficiency, efficiency with respect to particular species, and relative efficiency across seasons (Cameron and Pokryszko 2005, p. 540).

Samples are best obtained through a combination of litter collection (volumetric methods) and visual searching within the active season for most snail fauna (Cameron 1992 in Cameron and Pakryszko 2005, p. 543). Unless population density estimates are required, there is no particular merit in taking random quadrat samples. A standard volume of litter, taken from patches within the site and analyzed as a bulk sample, is easier to take, and at least as reliable for inventory purposes. There is no information in the literature as to the number of patches required; this varies from study to study and site to site.

Problems with adequate sampling are exacerbated by the rupicolous nature of Magazine Mountain shagreen (Caldwell *et al*. 2009, p. 17). The following protocol is based upon experience in studies of three different rupicolous snail species and Magazine Mountain shagreen life history information presented in Caldwell *et al.* (2009) and Robison (1996).

1. Four Magazine Mountain shagreen sites, spread across the geographic distribution area, will be monitored once yearly for five years. These include:

    a. USFS #1 (radio tower) on the west end of Magazine Mountain (Fig. 1);
    b. USFS #5 (Dripping Springs) as a middle site (Fig. 1);
    c. USFS #9 (Cameron Bluff) at the end of north face habitat below Magazine Mountain State Park (Fig. 2); and
    d. Bear Hollow locality (east end) below Benefield Picnic area and Magazine Mountain State Park (Fig. 3).

2. In Year 2 and 5, USFS Sites #2 – 4 and 6 – 8 (Figs. 1 and 2) will be monitored in addition to the four USFS sites listed in Number 1 above.

3. In Year 5, all 27 talus slope habitats identified by Caldwell *et al.* (2009) as Magazine Mountain shagreen habitat will be reassessed by the USFS, AGFC, and Service to determine habitat quantity and quality.

C. Sampling and Data Recording Procedures

Weather Monitoring

HOBO data loggers will be permanently placed at the four monitoring stations to record minimum and maximum temperature and relative humidity from March through June and during periods of prescribed fire on the north and west slopes of Magazine Mountain. In Year 2 and 5, the HOBO data loggers will be deployed during the same period at all monitoring sites. Daily precipitation records from March through June will be collected from the nearest recording station. Temperature, humidity and precipitation information will be maintained by the USFS in spreadsheet format.

Population Monitoring

Magazine Mountain shagreen monitoring will adhere to the following procedures:

1. Timed visual encounter searches (VES) are a standard practice. The most efficient procedure will be two to three-person teams conducting visual searches in optimal habitat for a total of 60 minutes (20 to 30 person minutes each) per site. Level of effort should be equal at each site and across years. Time (in minutes) to first live and dead Magazine Mountain shagreen will be recorded. All numbers should be reported as absolute numbers and relative abundance over all sites.

2. VES will be conducted approximately one hour after sunset in late April through May, dependent upon onset of spring rains and temperature (64–73 °F or 18–23 °C). Late winter or early spring weather fronts coming out of the west should be monitored to coordinate survey dates. One indicator on Magazine Mountain for onset of survey time is the emergence of oak catkins on trees bordering survey

sites. For example, at USFS Site #1 (radio tower), early catkins can readily be seen along a vehicle-accessible area and may serve as a good visual cue to begin monitoring temperature and relative humidity to determine appropriate sampling period.

Alternatively, if night surveys are not possible or practical, day surveys may be conducted. Day surveys must be done in the early morning with ambient temperatures approximately 64 °F (18 °C) and a relative humidity (RH) of 80% or greater. Caldwell *et al.* (2009, p. 17) data corresponds with Dourson (2008) who reported flat-spired three-toothed land snail (*Triodopsis platysayoides*), another rupicolous federally threatened species, to have greatest activity periods, day or night, at 64–73 °F (18–23 °C) and RH 70-85%.

2. Sampling will be conducted each year during similar temporal and climatic conditions (reference Number 2 above) based on the HOBO data loggers and recorded precipitation.

3. Sampling will be conducted by trained USFS biologists and technicians familiar with juvenile and adult Magazine Mountain shagreen identification, ecology, and habitat. This requires hands-on training.

4. Live Magazine Mountain shagreen and empty shells will be counted. Behavioral characteristics of live Magazine Mountain shagreen will be recorded for each site. For example, if live snails are dorsal side down, this indicates inactivity and snails may be secreting epiphragms for aestivation or over-wintering. Dorsal side up, no epiphragms, probably indicates an active snail that has withdrawn into the shell due to disturbance.

5. In Year 5, habitat quality and quantity will be assessed using methods outlined in Caldwell et al. (2009) for all 27 talus habitats on Magazine Mountain. Procedures for monitoring the land snail community are outlined below and will be used during PDM to assess habitat quality.

Inferences about populations and community structure are often based upon number of empty shells. While this is a useful metric, false conclusions may result (Carter *et al.* 2008 and Pearce 2008 in Caldwell *et al.* 2009, p. 17). Half life of empty shells of woodland species was found to be 7.5 years (Pearce 2008 in Caldwell *et al.* 2009, p. 17). Therefore, empty shell counts may represent historic not present numbers.

Magazine Mountain shagreen juveniles can be identified using characteristics presented in Caldwell *et al.* (2009). Therefore, care should be taken to look for juveniles. The number of adults and juveniles can be used to generate recruitment data. Hand lenses will be needed to determine Magazine Mountain shagreen juveniles by looking for the characteristic periostracal processes.

Land Snail Community Monitoring

Rather than monitoring for only one species (Magazine Mountain shagreen), habitat health will be determined by monitoring easily assessable duff and litter land micro-snail species (less than 5 mm). Caldwell *et al.* (2009, Table 6) lists relative abundance of land snails found in Magazine Mountain shagreen habitat. Six litter bags will be collected each spring and fall at each site and relative abundance should be determined. Trends would predict potential perturbations and decline in habitat health that would adversely affect Magazine Mountain shagreen. This could be done without snail identification expertise by simply identifying "species a, b, c, etc." and being consistent. However, litter bags should be sent to experts or trained USFS personnel for proper identification. Photographs of "species a, b, c, etc." will be taken each year to ensure proper identification and consistency with identification.

D. Practices to Assure Consistency of Data Collection

The following practices will be followed in order to minimize variability that could be introduced by inconsistent sampling practices:

1. USFS will be the primary entity conducting the PDM and employs multiple staff members that have conducted recovery monitoring and are familiar with locations and sampling procedures.

2. Biologists and technicians must be properly trained to identify Magazine Mountain shagreen and its habitat, must have a thorough knowledge of its ecology, and be able to accurately identify other terrestrial snail species.

3. Population monitoring will be conducted under similar temporal and climatic conditions (reference Number 2 above under Population Monitoring). Preferably, all surveys will be conducted at night.

4. HOBO data loggers will be deployed at monitoring sites between March and June of each year to monitor temperature and relative humidity.

5. Daily precipitation will be monitored between March and June of each year.

6. Annual reports will be submitted to the Service's Arkansas Ecological Services Field Office and AGFC for review and concurrence.

E. Frequency and Duration of Monitoring

The PDM period will be initiated during the first spring following the publication of a final rule to delist Magazine Mountain shagreen and will extend, at a minimum, through the fifth spring following delisting. Specific monitoring requirements are specified in Section IIIB – C above. The USFS will be the primary agency responsible for PDM.

IV. Definition of Response Triggers for Potential Monitoring Outcomes

Effective PDM requires timely evaluation of data and responsiveness to observed trends. In order to assure timely response to observed trends, it is necessary to identify possible outcomes from monitoring that could be anticipated and general approaches for responding to these scenarios. In order to identify thresholds that would trigger alternative responses in the case of Magazine Mountain shagreen, it will be necessary to analyze data from the recovery monitoring period to identify the range of variability that has been observed with respect to each of the variables that will be monitored during the PDM period. From this analysis, it will be possible to categorize observations into one of the following three possible PDM outcomes.

A. Category I

Magazine Mountain shagreen remains secure without ESA protections. This would be true if:

1. The mean numbers of live/dead individuals at each monitoring site based on VES sampling protocols, as previously specified, remains within the 75th percentile of mean values observed since monitoring for this species began in 1996;

2. Habitat quantity and quality remains stable; and

3. No new or increasing threats to the species are observed.

In this case, PDM would be concluded at the end of the timeframe specified in this Plan.

B. Category II

Magazine Mountain shagreen may be less demographically stable than anticipated at the time of delisting, but information does not indicate that the species meets the definition of threatened or endangered. This would be true if:

1. The mean number of individuals at each monitoring site falls between the 50th and 75th percentiles of mean values observed since monitoring for this species began in 1996;

2. Habitat quantity and quality declines by less than 15 percent; and

3. There are no new or increasing threats that are considered to be of a magnitude and imminence that may threaten the continued existence of Magazine Mountain shagreen within the foreseeable future.

In this case, the PDM period should be extended for an additional five years, and if necessary, sampling intensity could be increased to provide greater precision in detecting trends. Existing data will be analyzed to determine if any management interventions are available that would be expected to reverse declines and stabilize or improve trends.

C. Category III

PDM yields substantial information indicating that threats are causing a decline in the status of Magazine Mountain shagreen since the time of delisting, such that listing the species as threatened or endangered may be warranted. This would be true if:

1. The mean number of individuals at each monitoring site falls below the 50th percentile of mean values observed since monitoring for this species began in 1996;

2. Habitat quantity and quality has declined by greater than 15 percent; or

3. There are new or increasing threats that are considered to be of a magnitude and imminence that they could threaten the continued existence of Magazine Mountain shagreen within the foreseeable future.

If only the first of these conditions is true, then the Service should initiate a formal status review to assess changes in threats to the species, its abundance, population structure, and distribution to determine whether a proposal for relisting is appropriate. If all of these conditions are true, then the Service should promptly propose that Magazine Mountain shagreen be relisted under the Act in accordance with procedures in section 4.

V. Data Compilation and Reporting Procedures

Annual reports summarizing the PDM activities accomplished, data collected, and results will be submitted to the Service's Arkansas Ecological Services Field Office and AGFC. These reports should be prepared in a timely manner in accordance with this Plan to ensure that adequate data are being collected, to allow evaluation of the efficacy of the monitoring program, and to provide a periodic assessment of the status of Magazine Mountain shagreen. Each annual report will synthesize all monitoring data (population and climatic) and comment on observed trends and status of Magazine Mountain shagreen with respect to the PDM outcome categories presented in Section IV of this Plan. Annual reports are due by September 30 of each calendar year and will include all data collected since October 1 of the prior year (one fiscal year).

After five years of data are available, the field collection data will be reviewed to determine overall population change and status with respect to threats. We will compile this annual report data into a final monitoring report that will be made available to the public. The final monitoring report will summarize the data in the annual reports. It will include a description of the geographic areas surveyed, the survey protocol, and updated population numbers for each locality surveyed.

If the response triggers in Section IV above are met or exceeded, the Service will consult with the USFS, AGFC, ADPT, and other partners to determine whether to conclude the PDM process or to pursue alternative actions as described in Section IV. Our

determination also will include, if necessary, an evaluation of the threats to Magazine Mountain shagreen using the five factors required under the Act to list a species on the Federal List of Threatened and Endangered Wildlife and Plants.

VI. Estimated Funding Requirements and Sources

Post-delisting monitoring is a cooperative effort among the Service; state, tribal, and foreign governments; other Federal agencies; and other non-governmental partners under the Act. Although the Act authorizes expenditures of both recovery funds and section 6 grants to the states to plan and implement PDM, Congress has not allocated or earmarked any special funds for this purpose. To the extent feasible, the Service intends to provide funding for PDM efforts from annual Endangered Species general Recovery Program appropriations. Nonetheless, nothing in this Plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act (31 U.S.C. 1341) or any other law or regulation.

The primary entity conducting the PDM and preparing reports will be the USFS, who has accomplished or funded most of the recovery monitoring for Magazine Mountain shagreen. Based on USFS costs associated with recovery monitoring efforts, annual PDM expenditures for USFS should not exceed $3,000. The Service will provide assistance as needed and as resources permit, especially during the habitat analysis that is planned for the fifth year after delisting. Annual costs to the Service should not exceed $12,000 in each of the first four years and should not exceed $25,000 during year five.

VII. PDM Implementation Schedule

This schedule will be developed in coordination with the USFS, AGFC, and ADPT in order to ensure that it is feasible to accomplish PDM activities at all sites scheduled for a given year. The schedule will appear in the final Post-Delisting Monitoring Plan for Magazine Mountain shagreen (*Inflectarius magazinensis*) when it is published.

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